

any thing that might contribute to a publick Benefit, and to do some justice to Merit, could induce me, I shall only request that what I have here offered may be construed by that Intention.

Philad. 28th of
June, 1734.

J. LOGAN.

Note, That the Radius of the Quadrant being divided into 20 equal Parts, the Center \times (in *Fig. 1.*) of the Curvature of the Horizon-Vane (A B) must be $12\frac{8}{10}$ of those Parts from the Center (C) of the Quadrant. The Breadth (A B or *g b*) of that Vane should be $\frac{1}{10}$ of the whole Radius, that is, $\frac{1}{20}$ on each Side of the Center (C).

IV. *The Description and Use of an Instrument for taking the Latitude of a Place at any time of the Day; by Mr. Richard Graham, F. R. S.*

THE necessity of finding the Latitude, a Ship is in, is too well known to be insisted on: Frequent opportunities of observing the Latitude must consequently

consequently be of very great Advantage to Navigation. The Method usually practised, is by taking the Sun or Stars Meridian Altitude or Zenith Distance: In this Case, if the Sun does not shine but for some small Time only, before Noon and after, though it be clear all the rest of the Day, it is of no use for this Purpose. Mr. *Fatio*, *F.R.S.* (in the Year 1728) proposed a Method for finding the Latitude, from two or more Observations of the Sun (or Stars) at any Time, the Distance of the said Observations in Time, being given by a Watch; but as his Method requires a vast Number of Computations, and a great deal of Skill in Spherical Trigonometry, it has very seldom been made use of, and never but by good Mathematicians. The Instrument here described will answer the same End, and has these Advantages; *viz.*

- 1st, It may be very easily understood by Seamen.
- 2^{dly}, It immediately shews the Latitude of the Place.
- 3^{dly}, It gives the Time of Day at Sea when no other Instrument can.
- 4^{thly}, It may be made as large, and consequently as accurate as is desired.

A Description of the Instrument. See Fig. 2.

ABC represents part of the Hemisphere of a large Globe (half the Globe, and the Part below the Tropic are cut off, that it may take up the less room.) AC, half the Equator, divided into 12 Hours above, and 180 Degrees below, and subdivided into Minutes,

as is likewise the lower Tropick DD. EE, a moveable graduated Meridian, turning on the Axis FF. G an Index to fix it (by the means of the Screw H) to any Hour. I i I, a circular Beam-compass, the Center I i to be fixed on the Meridian to any Degree and Minute of Declination, by the Method commonly called *Nonius's* Divisions: k the Point for drawing Arches, which is likewise fixed to any Degree and Minute by the same Method. As the Meridian is at some Distance from the Globe, L is a piece of Brass to fix on the Meridian, marked with *Nonius's* Divisions, with a Point reaching down to the Intersection of the Arches, by which means the Distance of the said Intersection from the Equator, or its Latitude is found. The Degrees and Minutes may likewise be shewn by diagonal Lines.

The Use of the Instrument.

I. PROPOSITION.

From two Observations of the Height of the Sun, the Distance of the said Observations in Time, being given by a Watch, as likewise the Declination of the Sun; to find the Latitude of the Place, and Hour of the Day.

I. *When the Ship is at Rest, that is, at Anchor, or in a Calm, so as to have little or no progressive Motion.*

Case I.

Case 1. Suppose the Sun in the Equator, on the Day of Observation : Fix the Center of the Beam-compass at 0 Degree (or at the Equator,) and move the Point *k* to the Zenith Distance (the Complement of the Altitude, taken by the usual Instruments,) and from any Hour, as from *C*, describe an Arch of a Circle with the said Point, as *bc* (*Ex. 1.*) Suppose eight Hours after, by your Watch, you have another Observation ; move the Meridian eight Hours farther, to *d*, and fix it there ; and with the Zenith Distance then observed, describe another Arch as *ef*, the Point where it cuts the former is the Place of Observation, and its Distance taken on the Meridian from the Equator shews its Latitude ; and the Minutes reckoned on the Equator from the Meridian to *C* and *d* (the Times of Observation) shew what those Hours were.

Case 2. When the Sun has Declination : Fix the Center of the Beam-compass on the Meridian, to the proper Degree of Declination for the Day of Observation, and proceed as before.

Case, 3. If the Observations are at a greater Distance than twelve Hours, but in the same Day : Make use of the Complement to twenty-four Hours of the Distance in Time, and take the Declination on the contrary, or lower side of the Equator ; and instead of the Zenith Distances, take the Nadir Distances or Altitudes increased by ninety Degrees.

Thus

Thus you will find the Latitude, and Time of each Observation from Midnight. In this Case the Beam-compass must extend to more than 90 Degrees.

Case 4. If the Observations are more than a Day asunder ; as for Instance a Day and two Hours (26 Hours :) Place the Centre of the Beam-compass two Hours farther than it was the Day before ; but in different Declinations, according to the Table of Declination for the several Days.

Case 5. When the Observations are made by a Star : The Center of the Beam-compass must be set to the Declination of the Star ; then proceed as before. To find the Hour in this Case, the right Ascension must be likewise given.

Scholium. The same Method may be useful at Land, when no Meridian Observation offers.

II. *The Ship in Motion.*

Case 1. Suppose the Sun in the Equator : The Distance between the two Observations eight Hours, as before, and the Arch *aaa* (*Ex. 2.*) describ'd by the Zenith Distance of the first Observation, from the Center *C* ; and the Angle *cab*, 40 Degrees, is the Angle between the Ship's way, and the Azimuth of the Sun continued, (given by the Azimuth Compass ;) and that during the eight Hours, the Ship has made one Degree, or 60 Minutes from *a* to *b*, or from the Sun ; then,

then, as Radius is to the Cosine of $c a b$ 40 Degrees, so is $a b$ 60 Minutes to $a c$ 46 Minutes; add 46 Minutes to the Zenith Distance $C a$; and with k , the Point of the Beam-compass set at that Distance, describe the Arch $c b e$; then with the Zenith Distance of the last Observation, whose Center is d , draw the Arch $f f$; the Point where it cuts the Arch $c b e$, is the Place where the Ship was last; and its Distance taken on the Meridian from the Equator shews its Latitude; the Minutes reckoned on the Equator from the Meridian to d (the Time of the last Observation) shew the Hour, or its Distance from 12 o' Clock.

Case 2. If the Ship had sailed from a to β or towards the Sun: The Cosine of the Angle $\beta a \gamma$, or of the Angle between the Ship's Way and the Sun, must be subtracted from the Zenith Distance of the first Observation.

N. B. Only the two Arches $c b e, f f$, are to be drawn on the Globe, the rest being added here, to shew the Reason of the Construction.

Case 3. To find the Latitude of the first Place: From the Equator, with a pair of Compasses, take the Distance sailed 60 Minutes, and with one Foot in the Intersection of the Arches $b e, f f$, the Place found before, put the other in the Arch $a a a$, the Zenith Distance of the first Observation, and in this Instance, on the left Hand of the Azimuth of the Sun, this is the Place sought; and its Distance taken

ken on the Meridian from the Equator, shews the Latitude ; and the Minutes reckoned on the Equator from the Meridian to C, the Time of the first Observation, shew the Hour.

The Interval in Time or Degree between the two Places, shewn by the Index G, is the Difference of Longitude.

N. B. Those Observations are best, whose Arches cross each other almost at right Angles.

II. P R O P O S I T I O N.

The Zenith Distances of two Stars, observed at the same Time, their Declination, and right Ascension being known ; to find the Latitude of the Place of Observation.

Fix the Center of the Beam-compass to the Declination of either of the Stars, and with the Zenith Distance of that Star describe an Arch ; move the Meridian as many Hours farther as is the Difference of right Ascension of the other Star ; and fix the Center of the Beam-compass to the Declination of it ; and with its Zenith Distance cross the first Arch : The Intersection shews the Latitude of the Place of Observation ; and also the Distance of the right Ascension of the Zenith from that of either of the Stars, by which means the Hour may be known.

If a Celestial Globe is made use of, then place the Center of the Beam-compass over the several Stars.

The Latitude and Hour being given, the Variation of the Compass is easily known.

N. B. In order to draw Arches on the Globe; rub some black Lead powdered on a piece of Paper; lay the Side which is black'd next the Globe, where you imagine the Intersection of the Arches will be: Then draw them on the clean Side with the Point of the Beam-compass, and they will appear on the Globe; and if the Globe is well varnished, they may be rubbed out with Bread, or washed out with Water.

As Altitudes at Sea are now readily taken, with great Exactness, by the Quadrant invented by *John Hadley*, Esq; V. P. R. S. and as the said Altitudes are the Principles on which the Operations above described are founded; the previous Use of that Quadrant cannot but be of the utmost Importance to those who shall have Occasion for this Instrument.

The Description and Use of this Instrument was laid before the *Royal Society* Dec. 9. 1731; but as I knew Mr. *Reid* was contriving one for the same Purpose, I delay'd making mine Publick. His Method not yet appearing in Print, I have thought proper to communicate my own (especially as 'tis now improv'd) conceiving it may be of some Advantage to Navigation.

